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31 May 1965, DoDD 5200.10; USNSWC ltr, 14 May 1976

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U. S. NAVAL PROVING GROUND
DAHLGREN, VIRGINIA

REPORT NO. 1126

ARMY R&D AIRCRAFT ROCKET FUZES

4th Partial Report

- -

FUNCTIONING TEST OF P.D ROCKET FUZE T-2027

FINAL Report

Task Assignment Chief of Ord. TAI-2704

Copy No 8

Classification CONFIDENTIAL SECURITY INFORMATION

Functioning Test of P.D. Rocket Fuze T-2027

- -

PART A

SYNOPSIS

1. Picatinny Arsenal was requested by Army Ordnance on 26 October 1950 to develop a mechanical fuze for the 2.75 FFAR incorporating the clockwork type of arming mechanism found in the Navy Mk 176 fuze. It was further specified that the fuze should have a baffle delay type of detonator to provide impact functioning delay for defeat of aircraft.

Static tests at Picatinny Arsenal revealed that satisfactory delay times could be obtained when the baffle plates were removed from the delay detonator and that the standard deviation was decreased when this was done. Delay times of 539 microseconds were obtained with a standard deviation of 179 microseconds.

2. The objects of these tests were:

a. To determine the minimum thickness of aluminum target and maximum angle of obliquity against which the T-2027 fuze will function.

b. To determine the impact delay time against minimum and maximum target thickness.

c. To determine the impact delay times with the fuze conditioned at high and low temperatures.

3. It is concluded that the T-2027 fuze fired for target impact at velocities of approximately 2100 ft./second will:

a. Function with reasonable consistency on

(1) .020 or heavier aluminum alloy at 60° obliquity at ambient and elevated temperature.

(2) .080 or heavier aluminum alloy at 0° obliquity at -30°F.

(3) .250 aluminum alloy or mild steel at temperatures ranging from -30°F. to 130°F.

b. When detonating after impact on targets ¾125 and thinner, usually have a delay greater than 500 microseconds, but when detonating on ¾250 and heavier targets often have a delay less than 500 microseconds.

4. It is recommended that work be continued on the development of a delay element for the T-2027 fuze that will not (1) have its impact sensitivity reduced at low temperatures, and (2) have its delay time reduced when subjected to heavy impacts.

TABLE OF CONTENTS

PART B

INTRODUCTION

1. AUTHORITY:

These tests were conducted in accordance with Test Program Requests Nos. 3492, 3586 and 3609 of Picatinny Arsenal, submitted as enclosures to references (a), (b) and (c) respectively. Reference (d) authorized the conduct of the tests.

2. REFERENCES:

a. Picatinny Arsenal Conf ltr ORDBB-TE2 471.94/64-170 S. H. Rush/aom/6175 of 4 Sep 1952 with 0CO Conf 1st End ORDTA 0.0.471.82/1603(c) J. I. Kistle/rw/77803 of 15 Sep 1952
b. Picatinny Arsenal Conf ltr ORDBB-TE2 471.94/64-197 S. H. Rush/gjh/617 of 29 Dec 1952 with 0CO Conf 1st End ORDTA 0.0.471.82/1933(c) ORDBB-TE2 471.94/64-197 E. B. Andrews/pd/77803 of 6 Jan 1953
c. Picatinny Arsenal Conf ltr ORDBB-TE2 471.94/90-3 S. H. Rush/gjh/6175 of 25 Feb 1953 with 0CO Conf 1st End ORDTA 0.0.471.82/135(c) E. B. Andrews/rw/53775 of 5 Mar 1953
d. BUORD Restr ltr S78-1(26) Re2b-DBLaP:bjn of 11 Apr 1952

3. BACKGROUND:

Picatinny Arsenal was requested by Army Ordnance on 26 October 1950 to develop a mechanical fuze for the 2.75 FFAR incorporating the clockwork type of arming mechanism found in the Navy Mk 176 fuze. It was further specified that the fuze should have a baffle delay type of detonator to provide impact functioning delay for defeat of aircraft.

Static tests at Picatinny Arsenal revealed that satisfactory delay times could be obtained when the baffle plates were removed from the delay detonator and that the standard deviation was decreased when this was done. Delay times of 539 microseconds were obtained with a standard deviation of 179 microseconds.

4. OBJECT OF TEST:

a. To determine the minimum thickness of aluminum target and maximum angle of obliquity against which the T-2027 fuze will function.

b. To determine the impact delay time against minimum and maximum target thickness.

c. To determine the impact delay times with the fuze conditioned at high and low temperatures.

5. PERIOD OF TEST:

a.	Dates Project Letters	15 Sep 1952 6 Jan 1953 5 Mar 1953
b.	Dates Necessary Material Received	13 Oct 1952 to 2 Mar 1953
c.	Date Commenced Test	4 Nov 1952
d.	Date Test Completed	20 Mar 1953

6. REPRESENTATIVES PRESENT:

Mr. S. H. Rush Picatinny Arsenal

PART C

DETAILS OF TEST

7. DESCRIPTION OF ITEM UNDER TEST:

a. The T-2027 fuze is essentially the same as the Navy Mk 176 or EX-100 fuze, shown as Figure 1. However, the explosive loading in the rotor has been changed as shown in Figure 2. In this fuze it consists of an obturated primer and detonator with an air gap between them.

b. The firing pin has also been modified so that it now has a hemispherical tip rather than a point. The T-2027 fuzes used in this test were actually made from Mk 176 fuzes having the revisions noted above incorporated in them.

8. DESCRIPTION OF TEST EQUIPMENT:

Heads:	2.75 Mk 1 Mod 2, HBX-1 loaded and Comp B loaded
Motors:	5.0 Mk 10 Mod 5 (2 per round)
Head to Motor Adapters:	Aluminum, Picatinny Dwg. PX-8-539
Launcher:	NPG 1050 ft.
Targets:	.016 Aluminum 52SO Alloy, .020 to .250 aluminum 24ST alloy and .250 mild steel
Camera:	35mm Fastax
Velocity Measurements:	Solenoids with oscillograph
Fuze Delay Measurements:	.005 lead foil, photo-electric cell, Tektronix oscilloscope with Land Camera

Temperature conditioning equipment.

9. PROCEDURE:

a. Fuzes required to be fired at extreme temperatures were temperature conditioned in the loaded heads for 24 hours before firing. The 2.75 heads were assembled to 5" HVAR motors through the medium of special aluminum adapters. A second 5" HVAR motor was used in tandem as a "booster" to obtain higher striking velocities and increase the acceleration period of the rounds. This fuze requires a minimum acceleration of 20 G's to be maintained for at least one (1) second or it will not arm. The 5" HVAR motors were used rather than a 2.75 motor due to the short range available with this track which does not permit a 2.75 motor to attain full velocity. The targets were positioned 250 ft. beyond the muzzle of the 1050 ft. launcher during the first two (2) increments of the test and 400 ft. for the third.

b. Fuze delays were obtained in three (3) ways:

(1) Visually - the absence of fragment marks on the face of an expended target after a high order detonation indicated that the fuze had some delay. Cardboard placed on the ground just beyond the target provided a rough indication of the amount of the delay by the location of the fragment marks in them.

(2) High Speed Camera - the 35mm Fastax Camera film, operated at 2500 frames per second, provides a slightly more accurate measurement of the fuze delay.

(3) Photo-electric cell and oscilloscope record - measurements were made from the photographed pattern of a Tektronix Type 513-D cathode-ray oscillograph. The oscillograph sweep was triggered by the impact of the rocket on a .002 lead foil contact screen secured to the face of the target (separated from the target by an insulating sheet of paper). A photoelectric cell set up near the target detected the detonation of the head. The burst signal was applied to the vertical deflection input of the oscillograph. The time from the beginning of the trace to the detonation signal represented the functioning delay time of the fuze.

10. RESULTS:

a. Detailed results of the firing are presented in Appendix (B). Appendix (C) consists of excerpts from typical movie records of the target impacts.

b. Following is a summary of the results obtained:

All rounds fired with impact velocities between 1900-2300 ft./sec.

Summary of Results

No. Rds. Fired	Target Thickness	Obl. -30°F.	Fuze Funct. HO	Fuze Funct. Dud	Delay Microseconds	Delay Inches
8	.040 Al	0°	1	7	697	36"
2	.064 Al	0°	-	2	---	--
3	.080 Al	0°	2	1	700 - 840	15"-18"
1	.125 Al	0°	1	-	640	12"
1	.250 Al	0°	1	-	---	6"
4	.250 mild steel	0°	3	1	---	2"-12"

Functioning Test of P.D. Rocket Fuze T-2027

Summary of Results (Continued)

No. Rds. Fired	Target Thickness	Obl.	Fuze Funct. HO	Fuze Funct. Dud	Delay Microseconds	Delay Inches
		0°F				
2	.040 Al	0°	-	2	---	--
		Ambient				
2	.016 Al	0°	-	2		--
4	.020 Al	0°	2	2	697 - 789	--
7	.020 Al	60°	7	-	743 - 771	--
10	.032 Al	0°	8	2	558 - 794	--
2	.032 Al	60°	2	-	684	--
4	.250 Al	0°	4	-	342 - 403	--
4	.250 Al	60°	4	-	441 - 529	12"-36"
		130°F.				
6	.040 Al	0°	5	1	535 - 545	12"-24"

c. At low temperatures, 0°F. and -30°F., the T-2027 fuze did not function on targets as thin as it did at higher temperatures nor with as much reliability. At low temperatures, the fuze would not function satisfactorily on targets lighter than .080 aluminum (24 ST alloy). Functioning delay times after target impact were all above 500 microseconds on the rounds detonating.

d. At ambient and elevated temperatures, the fuze provided high order functioning with reasonable consistency on targets as light as .020 aluminum at 60° obliquity. Functioning delay times were above 500 microseconds on all except those rounds fired at .250 targets. It was also noted during the low temperature firing that extremely short delays were being obtained on the .250 targets. One (1) explanation of the reduced delay time on the heavier targets may be that the detonator is shifting forward upon impact deceleration and thereby decreasing the air gap between itself and the primer (Figure 2).

PART D

CONCLUSIONS

11. It is concluded that the T-2027 fuze fired for target impact at velocities of approximately 2100 ft./second will:

a. Function with reasonable consistency on

(1) ⅛020 or heavier aluminum alloy at 60° obliquity at ambient and elevated temperature.

(2) ⅛080 or heavier aluminum alloy at 0° obliquity at -30°F.

(3) ⅛250 aluminum alloy or mild steel at temperatures ranging from -30°F. to 130°F.

b. When detonating after impact on targets ⅛125 and thinner, usually have a delay greater than 500 microseconds, but when detonating on ⅛250 and heavier targets often have a delay less than 500 microseconds.

PART E

RECOMMENDATIONS

12. It is recommended that work be continued on the development of a delay element for the T-2027 fuze that will not (1) have its impact sensitivity reduced at low temperatures, and (2) have its delay time reduced when subjected to heavy impacts.

Functioning Test of P.D. Rocket Fuze T-2027

The tests upon which this report is based were conducted by:
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Rocket Battery Division
Terminal Ballistics Department

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Captain, USN
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By direction

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NPG REPORT NO. 1126

U. S. NAVAL PROVING GROUND
DAHLGREN, VIRGINIA

Fourth Partial Report

on

Army R&D Aircraft Rocket Fuzes

- -

Final Report

on

Functioning Test of P.D. Rocket Fuze T-2027

Project No.: Chief of Ordnance TA1-2704

Date:

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No. of Pages: 10

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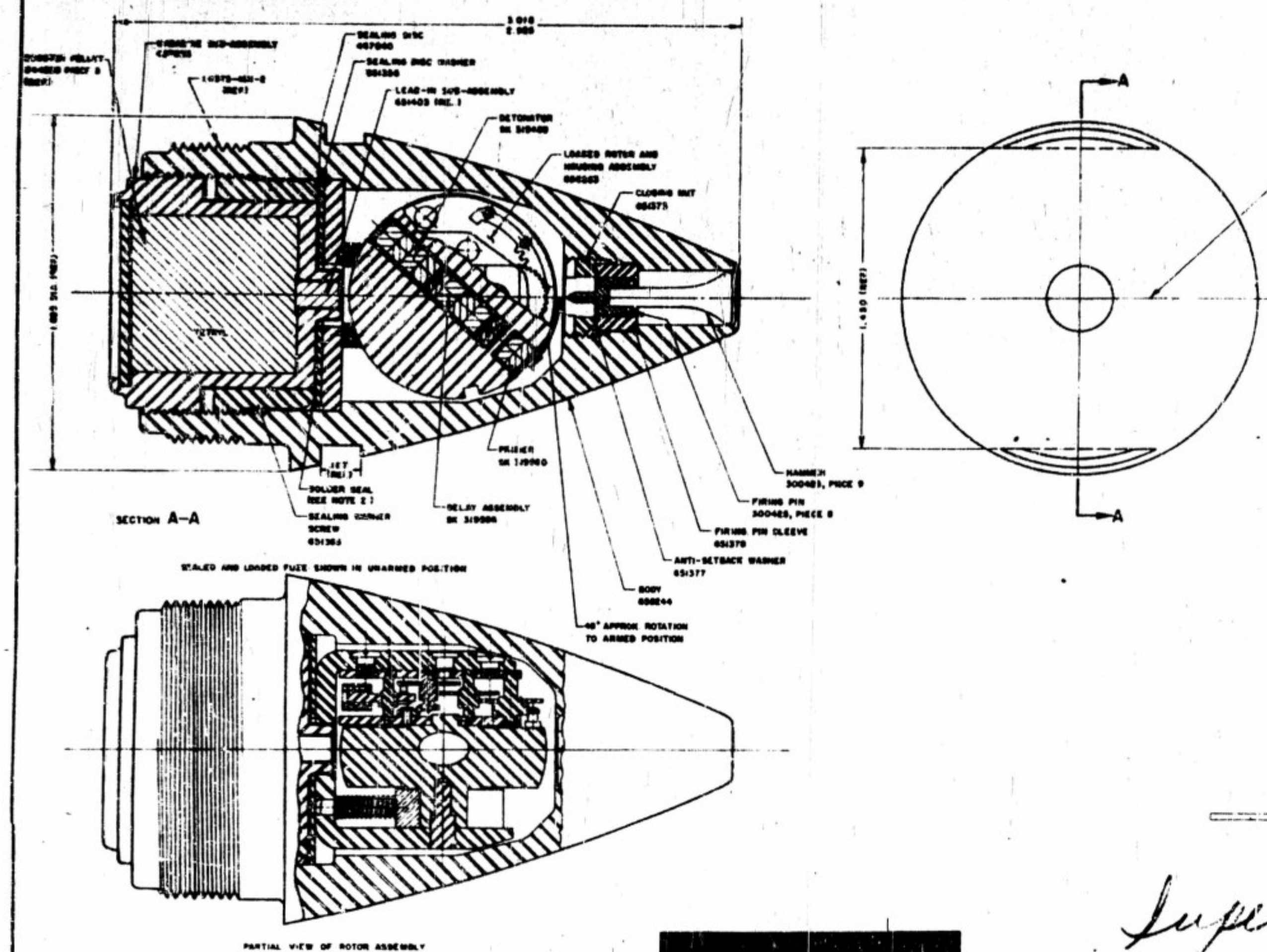

THE FOLLOWING INFORMATION SHALL BE SHOWN ON BODY USING DEPRESSED LETTERS AND FIGURES ABOUT 1/8 HIGH AND COLORED AS APPROVED BY THE BUREAU OF ORDNANCE

EX-100 MOD 1 (P.D.)

LOT NUMBER

MANUFACTURER'S INITIALS OR SYMBOL

LOT

INITIALS OR SYMBOL OF LOADING PLANT

DATE OF LOADING MONTH AND YEAR

INSPECTOR'S INITIALS

ANCHOR

NOTE

1 SPECIFICATIONS OF LATEST ISSUE APPLY

2 SOLDER SEAL TO BE IN ACCORDANCE WITH U.S. NAVAL ORDNANCE TEST STATION STANDARD PRACTICE [illegible]

3 ANY AND ALL REFERENCES TO COMMERCIAL TYPES, STYLES, TRADE NAMES, AND CATALOGS ARE INTENDED TO BE DESCRIPTIVE AND NOT RESTRICTIVE AND ONLY TO INDICATE THE CHARACTERISTICS OF ARTICLES WHICH WILL BE SATISFACTORY

4 FOR LIST OF DRAWINGS AND SPECIFICATIONS FOR FUZE, EX-100 MOD 1 (P.D.), SEALED AND LOADED, SEE L.D. [illegible]

5 FOR ORDNANCE SPECIFICATIONS GOVERNING THE MANUFACTURE, ASSEMBLY AND INSPECTION OF FUZE, EX-100 MOD 1 (P.D.) SEE NAVORD OS [illegible]

WEIGHT OF FUZE COMPLETE .... OUNCES APPROX

SCALE 1 INCHES

Superseded

[redacted]

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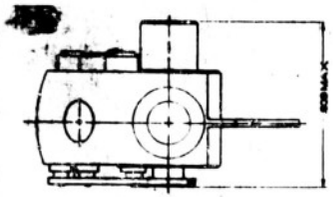
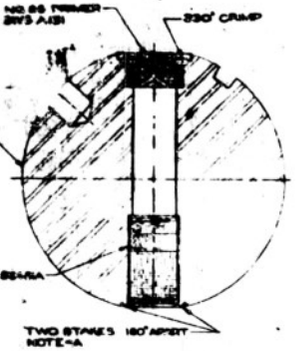
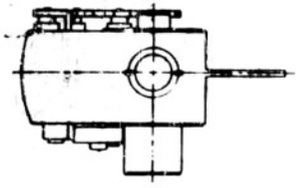
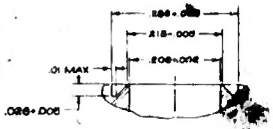
DO NOT SCALE THIS DRAWING	APPROVED FEB 1951	FUZE EX-100 MOD 1 (NOSE P.D.)	BUREAU OF ORDNANCE DEPARTMENT OF THE NAVY U.S. NAVAL ORDNANCE TEST STATION
MATERIAL		GENERAL ARRANGEMENT	DRAWING NO. 656269



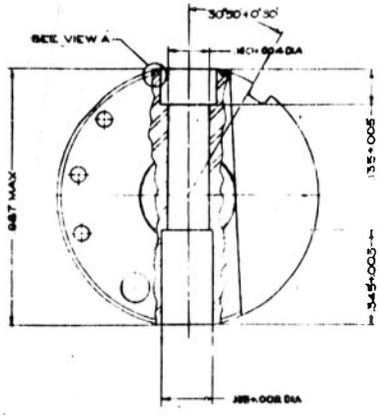




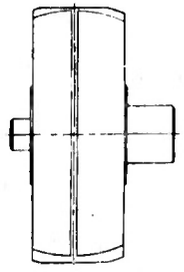
LOADING ASSEMBLY P-834784
FOR FURTHER INFORMATION SEE
DRAWING SUORD 467886



VIEW A



ROTOR P-834759
FOR FURTHER INFORMATION SEE
DRAWING SUORD 656251



NO.	LIST OF DRAWINGS	DRAWING NUMBER
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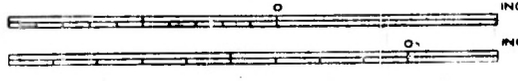
2	[illegible]	[illegible]
3	[illegible]	[illegible]
4	[illegible]	[illegible]
5	ROTOR	[illegible]

NOTES:
A- STAKES MUST NOT PROTRUDE ABOVE SURFACE OF ROTOR

S- FRANKFORD ARSENAL DWG
T- BUREAU OF ORDNANCE DEPT OF THE NAVY DWG

Figure 2



FUZE, ROCKET- PD T2027 ROTOR ASSEMBLY AND DETAILS

ORDNANCE CORPS DEPT OF THE ARMY

D 83479

Functioning Test of P.D. Rocket Fuze T-2027

TABLE I

TEST PROGRAM REQUEST NO. 3492 (HBX-1 LOADED HEADS)

Firing Record of T-2027 P.D. fuze in 2.75 rocket heads Mk 1-3
Fired from NPG 1050 ft. launcher with two (2) 5" HVAR Motors

Rd. No.	Date 1952	Temp. of Fuzed Head Deg. F.	Target - Al Thick Inches	Target - Al Obl. Deg.	Striking Velocity Ft./Sec.	Functioning	Delay Micro-Sec.
1	11-4	Ambient (60°)	.032	0	2009	HO	Missed
2	11-4		.016	0	2024	Dud	--
3	11-4		.032	0	2000	HO	704
4	11-4		.032	0	1979	HO	794
5	11-4		.032	0	2024	HO	575
6	11-4		.016	0	2032	Dud	--
7	11-5		.032	60	1962	HO	220
8	11-5		.032	60	1946	HO	684
9	11-5		.020	60	1984	HO	Inst.
10	11-5		.250	0	791*	--	--
11	11-5		.020	60	1982	HO	Inst.
12	11-5		.020	60	1998	HO	771
13	11-5		.250	0	N.T.	HO	394
14	11-5		.250	0	1986	HO	N.T.
15	11-5		.250	0	1976	HO	342
16	11-5		.020	60	1990	HO	Missed
17	11-5		.020	0	1996	Dud	--
18	11-7		.020	60	1946	HO	756
19	11-7		.020	0	1956	HO	789
20	11-7		.250	0	1944	HO	403
21	11-7		.020	0	1940	Dud	--
22	11-7		.020	60	1969	HO	743
23	11-7		.020	60	1969	HO	--
24	11-7		.020	0	1981	HO	697
25	11-7		.032	0	1914	Dud	--
26	11-7		.032	0	2002	Dud	--
27	11-7		.032	0	1958	HO	592
28	11-7		.032	0	1953	HO	640
29	11-7		.032	0	1973	HO	558
30	11-7		.032	0	N.T.	HO	Inst.

NOTES: Total Range to Target = 1315 Ft.
N.T. = Not Taken
Inst. = Oscilloscope Recorded Instantaneous Functioning
* Forward Motor did not burn; Malfunction

TABLE II

TEST PROGRAM REQUEST NO. 3586 (HBX-1 LOADED HEADS)

Firing Record of T-2027 P.D. fuze in 2.75 rocket heads Mk 1-3
Fired from NPG 1050 ft. launcher with two (2) 5" HVAR Motors

Rd. No.	Date 1953	Temp. of Fuzed Head Deg. F.	Target - Al Thick Inches	Obl. Deg.	Striking Velocity Ft./Sec.	Functioning	Delay Micro-Sec.	Delay Inches
1	1-29	Amb.	.250	60	1969	HO	Missed	36
2	1-29	Amb.	.250	60	1946	HO	529	36
3	1-29	130	.040	0	1982	HO	535	12
4	1-29	130	.040	0	1947	HO	545	12
5	1-29	130	.040	0	1951	Dud	--	--
6	1-29	130	.040	0	1938	HO	Missed	12
7	1-29	130	.040	0	1952	HO	545	12
8	1-29	Amb.	.250	60	1962	HO	441	12
9	1-29	130	.040	0	1992	HO	545	24
10	1-30	Amb.	.250	60	1917	HO	Missed	36
11	1-30	-30	.040	0	1923	Dud	--	--
12	1-30	-30	.040	0	1966	Dud	--	--
13	1-30	-30	.040	0	1927	Dud	--	--
14	1-30	-30	.040	0	2030	Dud	--	--
15	1-30	-30	.040	0	1969	HO	697	36
16	1-30	-30	.040	0	1935	Dud	--	--
17	2-6	0	.040	0	2154	Dud	--	--
18	2-6	0	.040	0	2181	Dud	--	--

NOTE: Total Range to Target = 1315 Ft.

TABLE III

TEST PROGRAM REQUEST NO. 3609 (COMP. B LOADED HEADS)

Firing Record of T-2027 P.D. fuze in 2.75 rocket heads Mk 1-3
Fired from NPG 1050 ft. launcher with two (2) 5" HVAR Motors

Rd. No.	Date 1953	Temp. of Fuzed Head Deg. F.	Target Thick Inches First	Target Thick Inches Second	Cbl. Deg.	Striking Velocity Ft./Sec.	Functioning	Delay * Micro-Sec.	Delay * Inches
1	3-19	-30	.040	.250	0	1923	HO -.250	---	6
2	3-19	-30	.040	.250*	0	2093	HO -.250	---	3
3	3-19	-30	.125	.250x	0	N.T.	HO -.125	640	12
4	3-19	-30	.080	.250x	0	2009	HO -.080	840	15
5	3-19	-30	.080	.250x	0	2304	Dud	---	--
6	3-19	-30	.064	.250x	0	2215	HO -.250	---	12
7	3-20	-30	.080	.250x	0	2239	HO -.080	700	18
8	3-20	-30	.064	.250x	0	2163	HO -.250	---	2

NOTE: *Photo-Electric Cell Trained on First Target Only.
When Fuze Functioned on second target no Oscillograph Record of Delay was obtained.
x These Targets were Mild Steel Plates, all others Aluminum.

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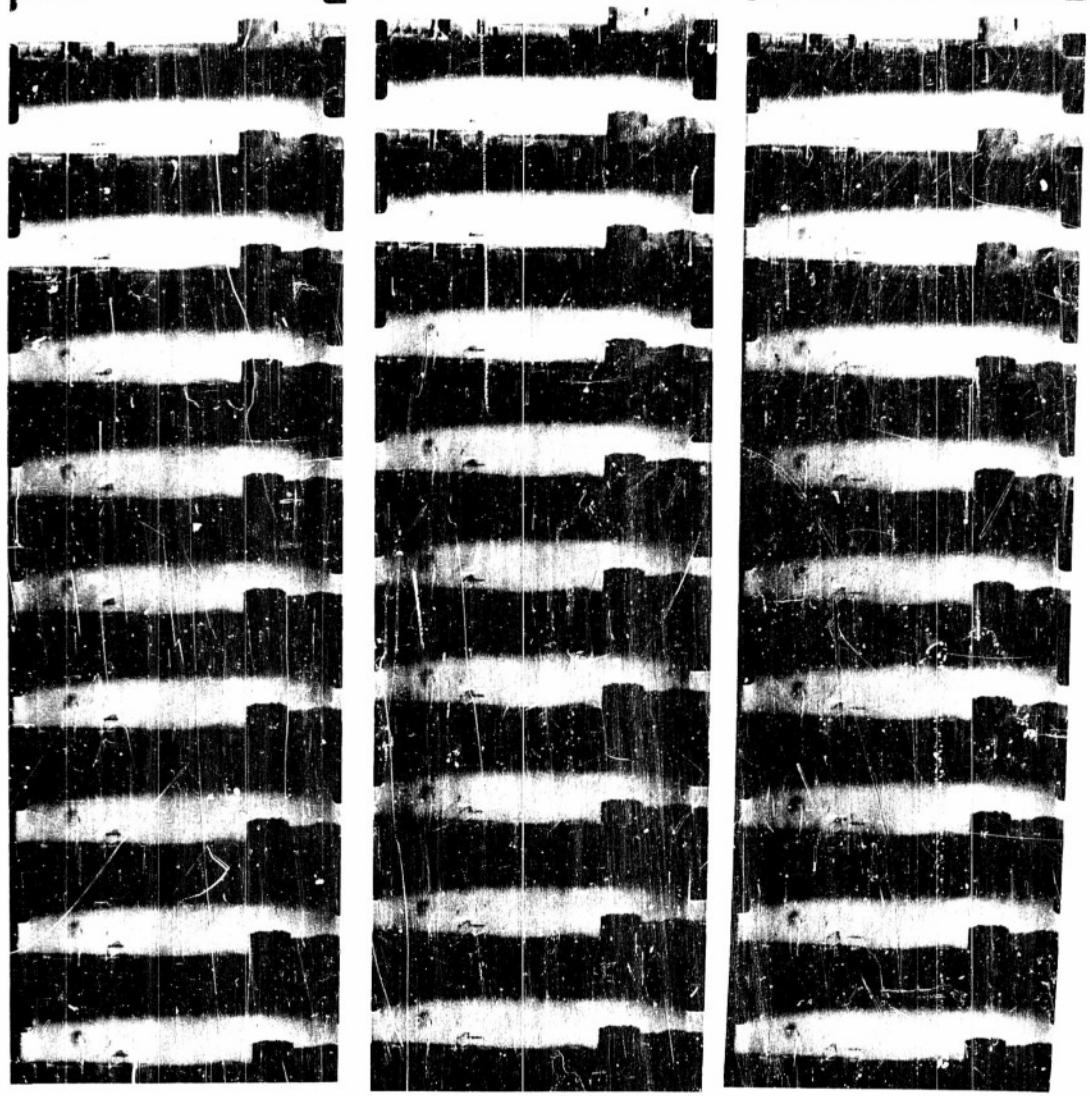
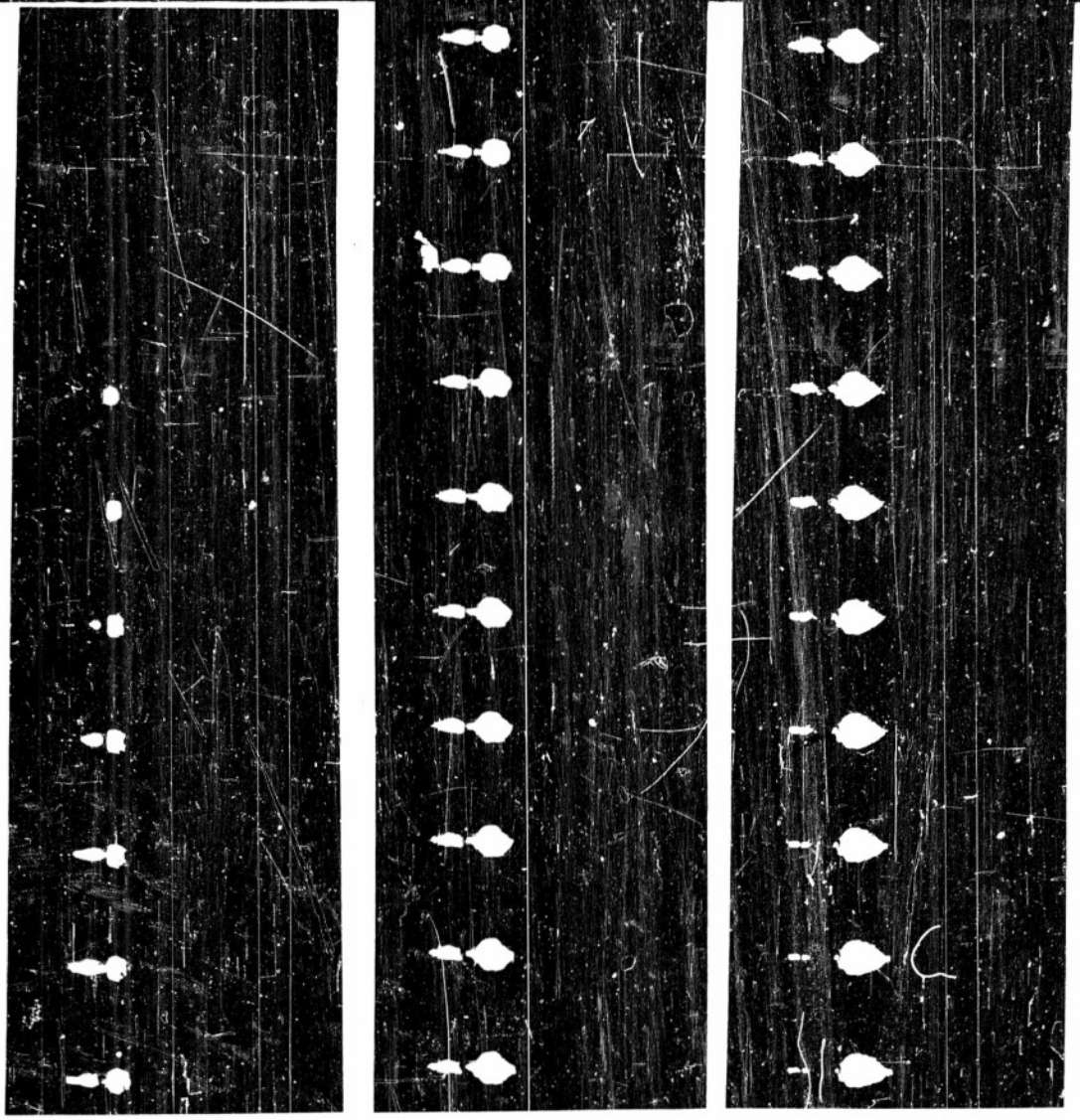
VP [illegible]19

Experimental ballistic test of T-2027 P.D. rocket fuze in 2.75 rocket head HBX-1 loaded. Fired from 1050 ft. launcher. View: Round No. 21 on TPR 3492. Dud operation on 7020 aluminum target at 0° obliquity at 1940 ft./sec.
Date Fired: 7 November 1952 Figure 3



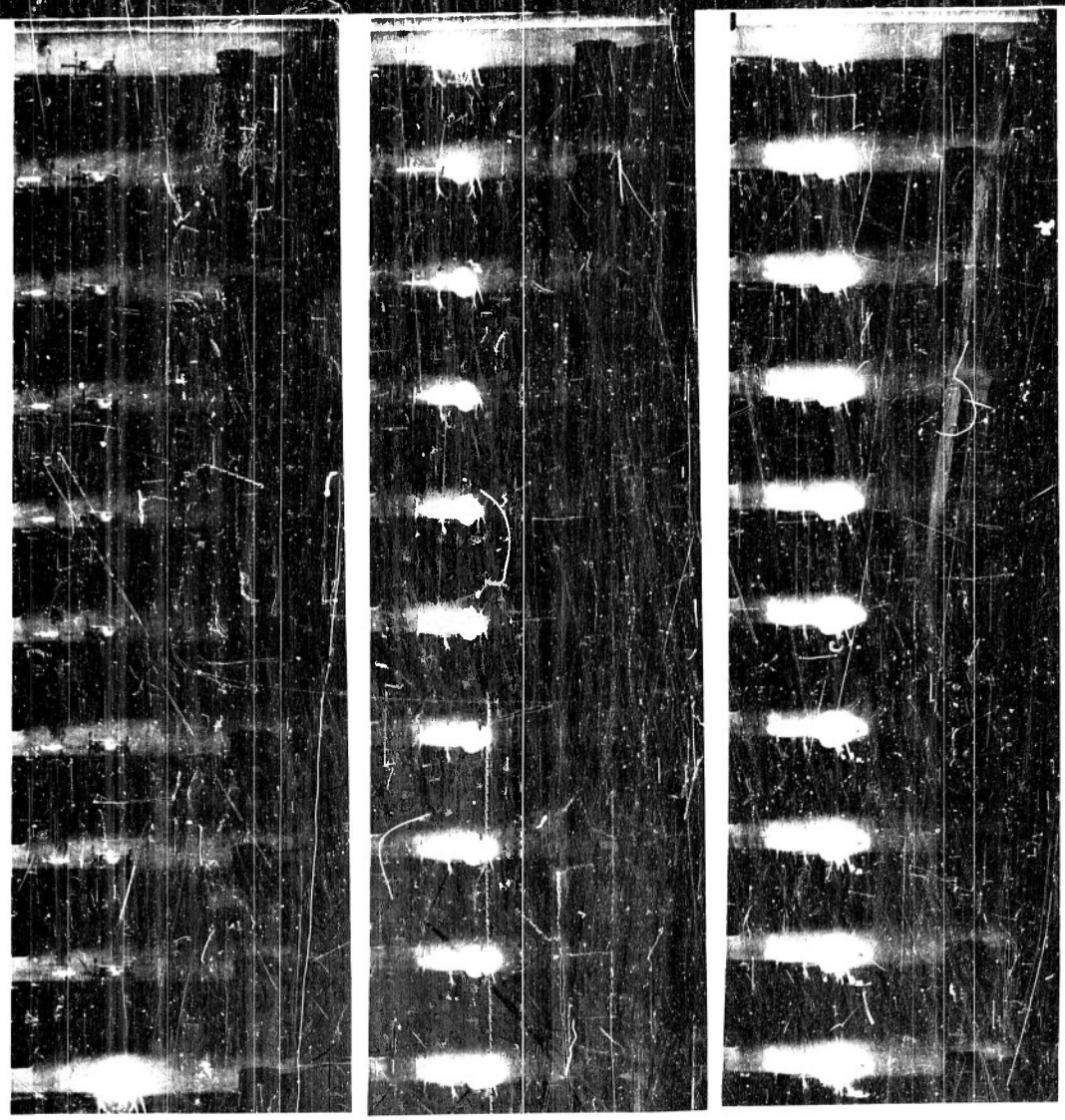
Experimental ballistic test of T-202 P.D. rocket fuze in 3.75 rocket head HE M-1 loaded. Fired from 1050 ft. launcher. View: Round No. 19 on TPR 3492. Fuze detonation on .020 aluminum target at 0° obliquity at 1056 ft./sec. Fuze delay [illegible] -seconds. Date fired: 5 November 1952

Figure 4



Experimental ballistic test of T-2027 P.D. rocket fuze in 2.75 rocket head HBX-1 loaded. Fired from 1050 ft. launcher. View: Round No. 1 on TPR 3402. NO operation on .020 aluminum target at 60° obliquity at 1946 ft./sec. Fuze delay 756 micro-seconds. Date Fired: 7 November 1952

Figure 5



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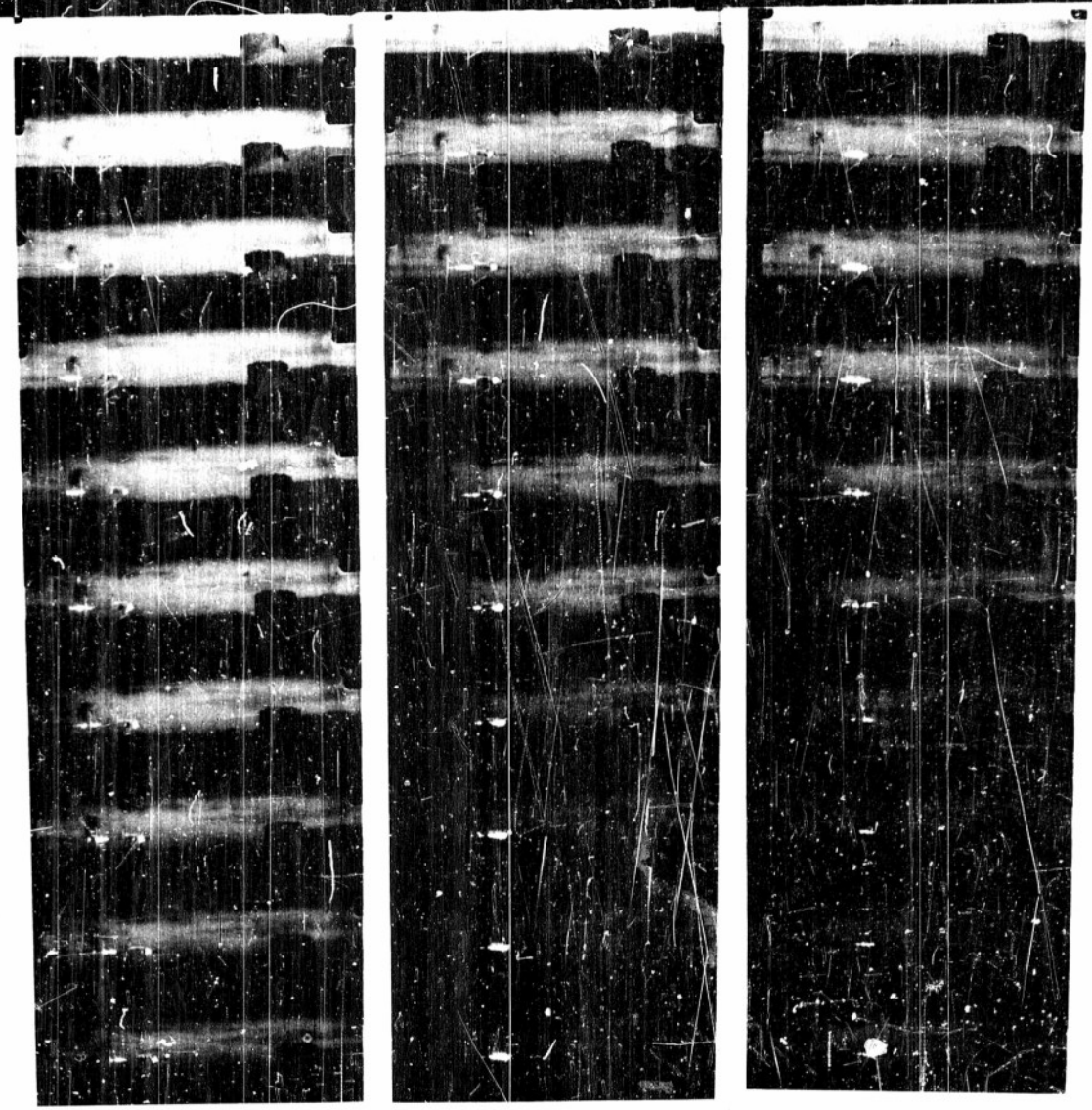
NPG-[illegible]
Experimental ballistic test of T-202? R.D. rocket fuze in 2"75 rocket head
HBX-1 loaded. Fired from 1050 ft. launcher. View: Round No. 26 on TPR 3492.
Dud operation on "032 aluminum target at 0° obliquity at 200? ft./sec.
Date Fired: 7 November 1952 Figure 6



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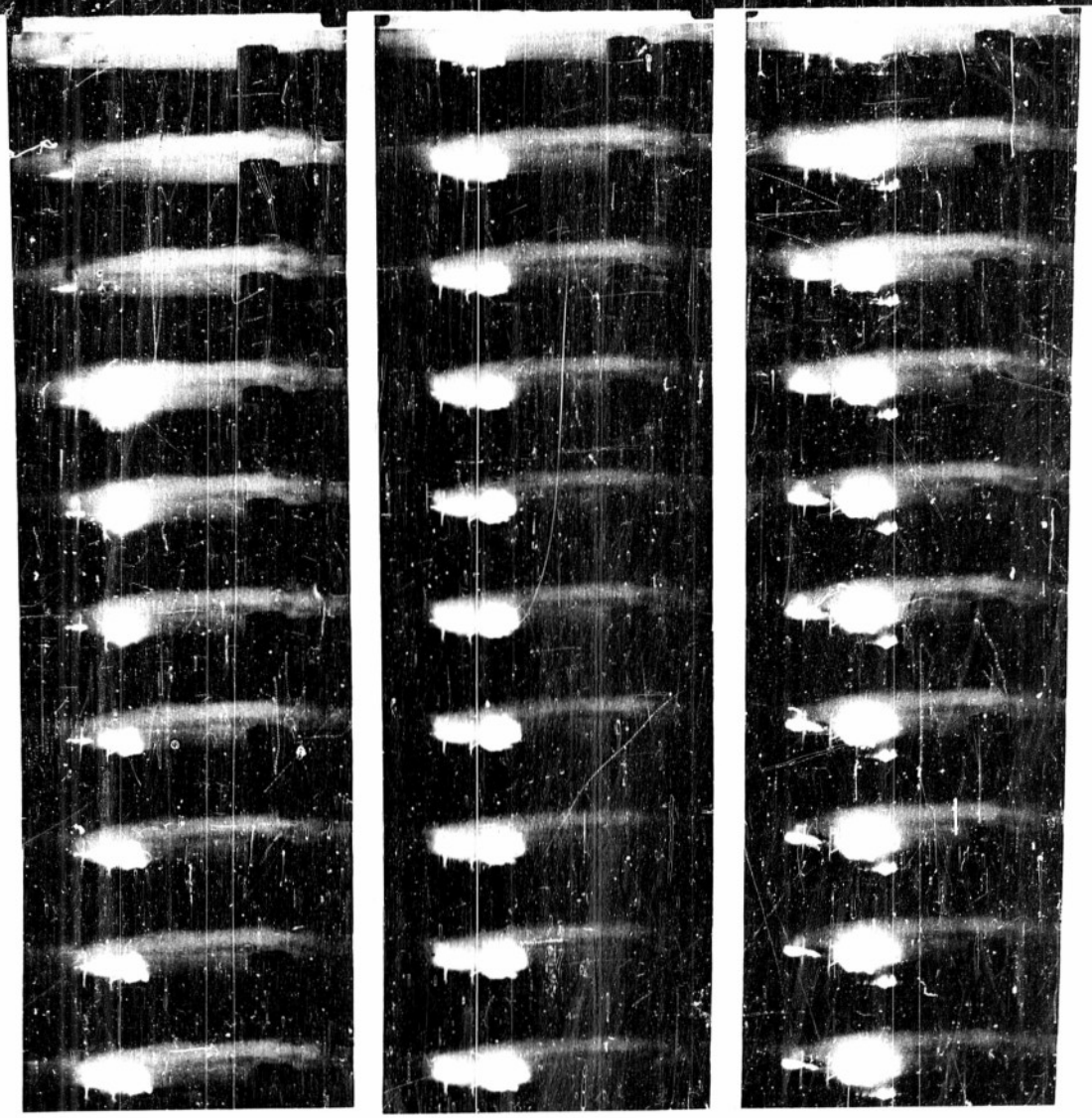
NRL-32823

Experimental ballistic test of T-2027 P.D. rocket fuze in 2.75 rocket head HBX-1 loaded. Fired from 1050 ft. launcher. View: Round No. 27 on TPR 3492. HO operation on .032 aluminum target at 0° obliquity at 1958 ft./sec. Fuze delay 592 micro-seconds. Date Fired: 7 November 1952 . Figure 7



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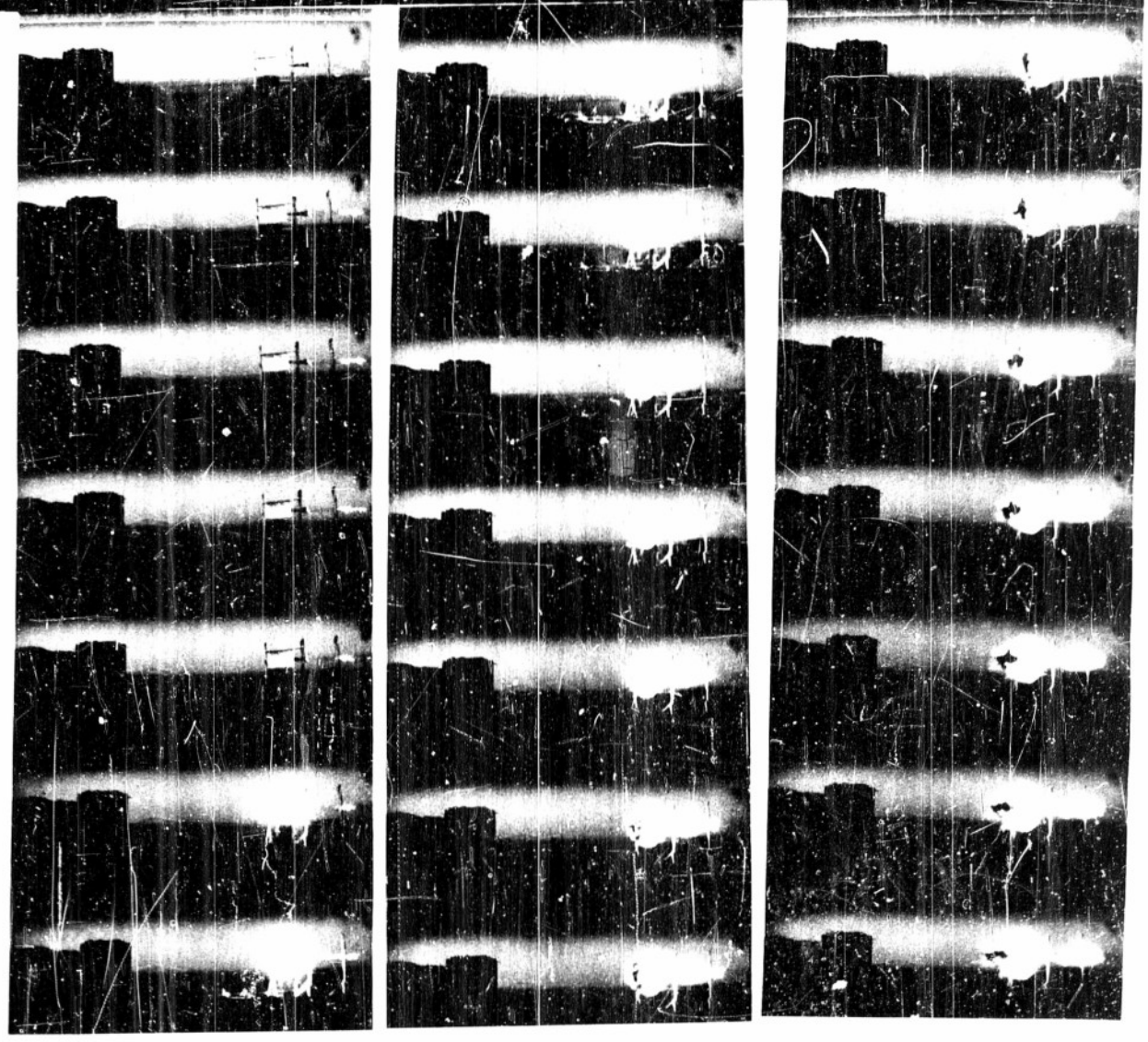
NPG-52324
Experimental ballistic test of T-202? P.D. rocket fuze in 2.75 rocket head HBX-1 loaded. Fired from 1050 ft. launcher. View: Round No. 8 on TPR 3492. HO operation on 7032 aluminum target at 60° obliquity at 1946 ft./sec. Fuze delay 634 micro-seconds. Date fired: 5 November 1952
Figure 8



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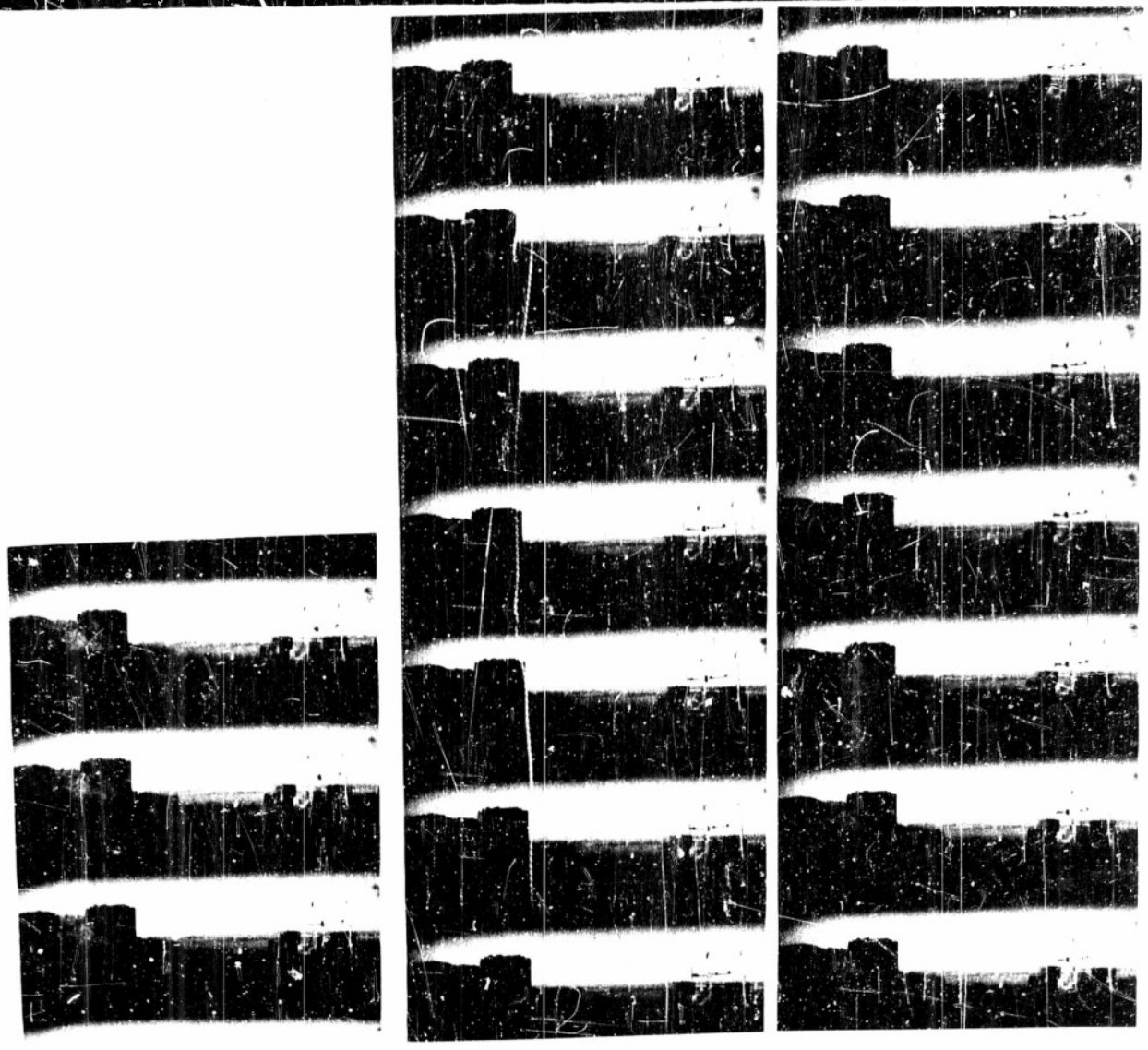
SECURITY INFORMATION

NP9-52225
Experimental ballistic test of T-2027 P.D. rocket fuze in 2.75 rocket head. HBX-1 loaded. Fired from 1050 ft. launcher. View: Round No. 10 on TPR 3492. Dud operation on 7250 aluminum target at 0° obliquity at 791 ft./second. Forward motor did not fire so fuze did not receive sufficient acceleration to arm. Date Fired: 5 November 1952 Figure 9



CONFIDENTIAL
SECURITY INFORMATION

NPO-[illegible]

Experimental ballistic test of T-2027 P.D. rocket fuze in 2.75 rocket head HBX-1 loaded. Fired from 1050 ft. launcher. View: Round No. 20 on TPR 3492. HQ operation on .250 aluminum target at 0° obliquity at 1944 ft./second. Fuze delay 403 micro-seconds. Date Fired: 7 November 1952

Figure 10